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Effect of gender difference and survey design in a tool usability testing

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Effect of gender difference and survey design in a tool usability testing

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The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this thesis. The Graduate College will ensure this thesis is globally accessible and will not permit alterations after a degree is conferred.

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ABSTRACT

Good user satisfaction facilitates a company to confirm its value and also is the key to secure customer loyalty and achieve the goal of competitive advantage. User satisfaction can be measured by many market research techniques. A common approach nowadays is usability testing. In the process of the measurement of user satisfaction, we believe the impact of gender difference cannot be ignored. Because of the physical and psychological differences between men and women, their perceptions of things are also affected. Thus, taking this effect into account during the usability testing process may be helpful in the evaluation of a product.

In addition, the use of a questionnaire as a survey method was widely used and proven effective in previous studies to collect data from users in many fields, such as internet service, digital equipment, public transportation, housing, banking industry, etc. A well-designed questionnaire has a positive impact on user's comprehension of the questions and the whole user testing process. Researchers have been developing good solutions to help respondents understand the questionnaire. Some studies also attempted different survey methods to help respondents answer image-based surveys and video-based Web surveys.

This paper reports a tool study of people's gender influence on subjective perception in a drill usability testing based on the questionnaire survey method, and it reports how the perception and survey influence their feedback.

To determine the characteristics of an electric drill that the user prefers, we designed a questionnaire survey for people who possibly have a demand for an electric drill to meet the needs of daily work and life in the future. The questionnaire was used for two purposes: one was to ask the participants to rate the comfort level of their muscles in the experiment, and another was to collect their feedback on the design and form of the questionnaire itself. In this study, we

tested their satisfaction with different concerns of three different makes and models of electric drills. This study has three assumptions. The first one is that male participants and female participants have different concerns about the use and purchasing of drills. The second one is that a questionnaire survey can influence the decision participants make for product selection. The third one is that, compared to the electronic form questionnaire with only questions, visual assistances help make it easier for participants to understand the questions and review the experience.

The results show in this case that gender difference has no significant impact on the feature concerns of the drill, even the drill preference and the total evaluation of the drill. The results regarding the second hypothesis show the questionnaire did not have a significant impact on people's preference of the drill but did help them to make easy and better decisions. For the survey method comparison, the results show the video survey was not accepted by half of the participants. The best questionnaire form was to have questions with image assistance, which effectively helped participants better understand the questions.

Even though these results may not be very helpful in the development of the usability of power tools due to some limitations in the study, the survey method part could be a reference to a future study in helping with questionnaire design and development.

Future related work could also consider the limitation of this study as a reference to help develop better investigation.

CHAPTER 1. INTRODUCTION

In recent decades, user satisfaction has become an important issue for commercial and public service organizations (Fečiková, 2004). For firms in the market, achieving better user satisfaction by making effort to meet their customers' demands is the key to ensure their survival, secure customer loyalty and achieve the goal of competitive advantage (Imam, 2014; Sweis et al., 2013; Atarodian, 2013). Good user satisfaction facilitates a company to confirm the previous efforts and constantly generate valuable products into the market. Analysis of user satisfaction was found useful for the improvement of products and services (Li et al., 2010). User satisfaction can be measured by many market research techniques, such as user satisfaction survey methodologies, focus groups to study user satisfaction issues, standardized packages for monitoring user satisfaction, and various computer software (Fečiková, 2004).

In recent years, questionnaire survey method was widely used and proven effective to collect data from users in many fields, such as internet service, digital equipment, public transportation, housing, banking industry, etc. (Isaac et al., 2017; Varsaluoma & Sahar, 2014; Imam, 2014; Sweis et al., 2013; Atarodian, 2013). This research reports a power tool study of participant's subjective visual and haptic (relating to touch) perception in a screw driving task based on the questionnaire survey method, and it reports how the perception influenced their feedback of different power tool products. Because a power drill is a common tool in industry and has a growing market size of usage, it was selected as the experimental equipment of this study.

1.1 Gender Difference Influence

In the process of the measurement of user satisfaction, the feedback caused by gender differences cannot be ignored. During the process of purchasing, gender difference always has a significant impact on the results (Coley & Burgess, 2003, Kruger & Byker, 2009). From the perspective of evolutionary psychology, the gender difference is not only because of the structural differences between brains, bodies and genetic variations but also derived from the phenomenon that men and women have faced different adaptive problems over human evolutionary history (Buss, 1995). Among our early ancestors, men were often responsible for hunting activities in groups based on their physical advantages, while women were responsible for gathering fruits, tubers, and other edible resources in groups, as well as taking care of and raising offspring (Tifferet & Herstein, 2012, Marlowe, 2007). As time goes on and society develops, this kind of role division gradually evolved into the fact that modern males pay more attention to the improvement of self-capability and skills and the psychology of pursuing mastering and controlling things. Females, on the other hand, focus more on details and aesthetic, showing an advantage in maintaining emotions and family life. Moreover, in the process of processing information, women are more likely to attempt to gather all available information, while men tend to rely on a single cue which is readily available during processing (Kempf et al., 2006). Therefore, influenced by these psychological differences, men and women also have different concerns about consumption. For instance, when purchasing a product, male consumers consider more about their needs and motivations with less patience to compare with the competitors, while female consumers are more susceptible to other external factors, such as shopping environment, product marketing, practical value, emotion, and other competitors. In this study, in order to further understand the gender difference in the consideration of purchasing a hand tool product, a drill usability test was conducted to determine the different concerns of the same product between male participants and female participants.

1.2 Usability of hand tools

Usability testing is a common way to evaluate the usability of a product or service in many fields. It requires the participation of real people, and an interaction with the objects to be tested. In recent decades, researchers have done different investigations based on the usability of hand tools. Kuijt-Evers et al. in a study investigated the factors which influence the comfort in using hand tools. They found that user's comfort in using hand tools is most related to the tool's functionality and followed by physical interaction between the users and the tools and appearance (Kuijt-Evers et al., 2004). Two years later, in a hand tools study by the same group of people, the differences of the comfort descriptors between different kinds of hand tools was further indicated. They conducted the study with hand tools such as screwdrivers, paintbrushes, and handsaws and concluded several most important comfort descriptors from the subjects such as 'Has a nice feeling handle', 'fits the hand' and 'offers a high task performance' (Kuijt-Evers et al., 2007).

In another usability study, a strong association between safety and usability perception was found. Participants rated tools differently in terms of perceived tool usability and safety within class of tools. The differences in ratings did not appear to be driven by the tool design or dimensions, but the differences in personal experience and reported confidence with use of the tools (Seol, 2005). This study mainly identified the positive correlation between the safety and usability of hand tools and personal experience. In addition, in more recent research, Matthiesen et al. conducted a study on the usability of power tools based on the influence of the tool brands. The study indicated a significant brand influence with a strong positive effect on well-known brands and a negative effect on unknown brands (Matthiesen et al., 2018). This conclusion brought more possibilities to the evaluation of power tools.

Just like the studies above, most researchers consider the usability of hand tools based on the tool's functionality, appearance, and subjects' perception and experience. However, a relationship was not disclosed between subjects' gender difference and their preference in purchasing hand tools. Therefore, because of the psychology difference between males and females, a possibility of preference difference in the selection of drills may exist.

1.3 Power Drill in Industry

In this era of rapid industrial development, as a very common tool in the industry field, the power drill always plays an important role and has huge market demand. Because of the huge market demand and the nature of the drilling work, the quality of an electric drill becomes quite important and competitive in the industry. A power drill is a drill driven by an electric motor that rotates a replaceable drill bit to make a hole in wood, plastic, metal or other materials (Fix-It Club, 2007). It is widely applied in the construction industry, medical field, and geological work. For different purposes in the industrial field, power drills are mainly classified into four types: corded drill, cordless drill, hammer drill, and rotary drill. Among these four types, corded drills and cordless drills are two typical tools with a pistol-grip design. This research focuses on the cordless drill which is becoming much more popular in household usage nowadays. A cordless drill, also known as a drill driver, is a portable electric drill with a rechargeable lithium-ion battery or a nickel-chromium battery. This kind of power drill is designed to be easily used for driving in and out of screws and drilling all kinds of metal and wood. It does not need an external power supply when working, so it is suitable for carrying and using in the field even without a power supply. As the demand for cordless drills is going high, the number of competitors in the market is increasing. With plenty of similar products existing in the market, users always prefer the best one according to their opinions. There are many reports online such as DrillPressView, PowerToolBuzz, CordlessDrillZone, Consumer Reports, etc. that reflect user reviews of some common brands of cordless drills with the ranking of the best. It seems lots of reasons show why the brands of drills correspond to their ranking. However, it is obvious to see that there is not a fixed ranking which really reflects the best and the worst. Each report reflects the ranking from different angles according to a user review. Some of them do not provide the details of the user feedback, which makes it difficult and inconvenient for further users to make the right decision. In this study, for a better comparison of power drills' usability and to better understand what users think about the product in a certain environment, the user's gender, questionnaire's influence, and drill types were considered as three major factors.

A screw driving task with given tools was conducted. Three power drills from highly rated brands—Milwaukee 2702-20 M18, Makita XPH12 and Porter Cable PC1801D—were selected for the drill's usability testing. All these drills are similar in some features and functions but still have some noticeable differences such as control, appearance and comfort. In order to better understand these differences between the three power drills, product analysis based on usability were conducted. All three drills were 18V cordless multi-mode drills with a pistol-grip design and two-speed options. Milwaukee 2702-20 is the medium size among the three selected drills and weighs 3.9 pounds with battery. Makita XPH12 is the smallest size among the three selected drills and weighs 4.0 pounds with battery. Porter Cable PC 1801D is the biggest size among the three selected drills and weighs 5.1 pounds with battery. The specifications of all three power drills were found from the user manual and some review websites (milwaukeetool.com, makitatools.com, drillanddriver.com).

1.4 Questionnaire Survey Comprehension

Survey as a methodology of data collection, plays a vital role in the usability testing process. A survey usually can be classified into two methods, quantitative and qualitative, depending on the nature of the research (Andres, 2012; Groves et al., 2011). Quantitative method gathers either the descriptive statistics data, which describes the size and distributions of various attributes in a population, or the analytic statistics data, which measures how two or more variables are related, while the qualitative methods focus on gathering information with deep understanding of the perspectives of the subjects (Groves et al., 2011). In this study, to better understand the relation between each variable, quantitative method was used.

Commonly, to collect the data, a survey can be divided into two categories: the questionnaire and the interview (Trochim & Donnelly, 2001). Questionnaire is usually used for a large sample size with simple and easy-answer questions, while the interview is used for gathering the information based on the personal's viewpoint and more details. In consideration of the types of data and time factor, in this study, we use the method of mixing questionnaire and interview.

The questionnaire types have been divided into many different versions, such as mail, telephone, and electronic surveys. An interview can be conducted in person (face-to-face), over the phone, or through collaboration technologies such as chat (Wilson, 2013). Before the explosive development of the Internet, mail and telephone were the two traditional questionnaire versions people used for collecting data and feedback in research. Nowadays, the electronic questionnaire as a very common type of survey is widely used in the research process and product evaluation. In this process, a good questionnaire can help users efficiently understand all the questions and generate effective results for further analysis of the study. A terse and well-designed questionnaire not only depends on the question itself but also the respondents' comprehension of it. In a summary of survey methodology made by Redmiles et al. in 2017, respondents' comprehension is the first step of the process of responding to a given questionnaire or interview item, while the other three steps are related to how the respondents process the information provided into the question and report their answer (Redmiles et al., 2017). To better understand the survey questions, users not only base their answers on the comprehension of common vocabulary, but also on the terminology in terms of the research field. In this segment, subjects' comprehension of the questions directly influences their answers and feedback of the questionnaire, which could result in the later data analysis process in either an anticipated result or not. Comprehension ability is closely related to background knowledge, personal experience, and learning ability.

Many factors can influence this process such as word choice, question context, survey length, specific study modes (e.g. online or face-to-face) etc. (Redmiles et al., 2017). Among these factors, word choice is very important to help respondents successfully complete the questionnaire. Otherwise, it could cause potential problems and have a bad impact on the data collection. Therefore, researchers have been exploring solutions to help respondents understand the terms in the questionnaire. Bradburn et al. found that identifying and using terms which respondents are more familiar with is feasible and resulted in more accurate responses (Bradburn et al., 1979). In addition, focus groups and questionnaire pre-testing were also developed to help ensure respondents consistently read and understand the definition (Tourangeau et al., 2000; Forsyth et al., 2004; Presser et al., 2004; Groves et al., 2011; Redmiles et al., 2017). Graesser et al. also developed a Web facility called Question Understanding Aid (QUAID) that assists survey methodologists in identifying problems with the wording syntax and semantics of questions on questionnaires (Graesser et al., 2006). These studies were based on revising the terms themselves in the questions, but what if using other tools such as with an image to describe the terms in the questionnaires to help the respondents to understand the questions with the terms hard to be changed?

Many empirical studies have attempted different approaches to improve comprehension ability during learning process. Some student-oriented studies started with the improvement of the subjects' self-capability through teaching them reading skills, while others mainly directed to people with dyslexia provided visual and aural assistance tools such as image and audio (Lei et al., 2010; Koch & Eckstein, 1991; Woolley, 2010; Clark et al., 1984). The results of these studies did show a positive effect on improving comprehension. However, most of the studies were conducted from the subjects' own perspective. Very little research started with the questionnaire and amount of the reading material, except for experiments directed to the specific populations.

In addition, to better understand how well a user answers the questions, some previous studies conducted the survey with a video in it. Fuchs and Funke conducted an experiment which randomized comparison of a traditional text-based Web surveys to a Web survey containing videos of an interviewer reading the questions to the respondents. However, although the results showed the respondents really enjoyed the video, the author still did not recommend to adopt this method in a Web survey, because it did not provide compelling evidence that the Web survey with the video would yield superior quality data, which also cost more and benefit less (Fuchs & Funke, 2007). Moreover, Shapiro-Luft & Cappella also indicated in a related investigation that include videos within the Web survey has the potential to undermine the accuracy of study findings and distort the representative nature of the study sample due to some objective factors, such as the ability to view videos and the test environments of the respondents (Shapiro-Luft & Cappella, 2013).

However, in another study of displaying video in Web surveys, the authors compared the influence of two survey modes (one with image and the other one with video) on prompting respondents' memories and indicating their recall of television advertisements, and found that the video-based question format was more effective than image stimuli (Mendelson et al., 2017). These results indicated the possibility of using videos in Web survey to gather data. Although these studies were related to the comparison of survey mode with videos, there is little existing study of video-based survey in usability testing process. In the present study, to better compare the influence of survey methods in a usability testing, videos were added into the process to help participants answer the questionnaires.

This study compared three different forms of questionnaires, all with the same questions, to test the difference in participant's comprehension and final results. The first form of the questionnaire only consisted of questions. The second one consisted of images to assist understanding. The third one consisted not only of images as an assistance tool but also a video that showed the experimental process to help participants answer the questions.

1.4 Research Hypothesis

Based on the preceding information regarding each drill's usability and the design of the questionnaire, there are several hypotheses which include:

1. Female participants and male participants pay separate regard to different features of power drills, both using and purchasing conditions, as well as have different perceptions of the same features.
2. The questionnaire influences the decisions participants make for product preference.
3. A questionnaire with visual assistances helps participants better understand the questions and review the process of the experience.

CHAPTER 2. METHODS

2.1 Participants

A total of 36 volunteers participated in this study (18 males and 18 females). The participants were recruited through verbal announcements, fliers, and word-of-mouth. All the participants were local residents over 18 years old, able to read and speak English, and able to operate a hand-held electric drill. 28 of the participants had experience of using power drills. The data from one male participant was excluded due to equipment failure.

2.2 Equipment

Three cordless power drills with battery, Milwaukee 2702-20 (Figure B1), Makita XPH12 (Figure B2), and Porter Cable PC1801D (Figure B3) were selected for the comparison of the usability in this study. All three drills were setup in screwdriver mode and same speed level before the test.

Pieces of lumbers were set up for participants to finish the drive-in and drive-out process of the screws (Figure B4).

A box of star flat-head deck screws (hundreds of screws) were used in the experiment for participants to drill into the surface of the lumber (Figure B5).

Different sizes of gloves and goggles were provided to participants to avoid injury in the experiment (Figure B6).

Seven electronic questionnaires (Appendix: C) with two forms (with and without images) with exactly the same questions were conducted in this study. Six of them collected the feedback of a participant's perception of their body and hand muscles. The other one collected feedback on the comparison of the three tools.

A video was showing a tester who was testing the same screw driving task as the participants with all three drills.

2.3 Procedures

Participants were evenly divided into three groups (one with the classic questionnaires, one with the questionnaires with images, and the other one with the questionnaires with images and videos) and did the same screw-driving task. Before the experiment started, participants were given gloves and goggles to avoid injury in the experiment. At the same time, the participants were introduced to the entire experiment process and how to safely operate the power drill to drive screws into the wood surface. The participants then were randomly assigned the experimental drills to finish the training process before the formal test. During this process, participants had to finish the drive-in and drive-out of the screws from the assigned wood board surface with at least 2 screws for each tool. Then after a 2-minute break, the formal test start. Participants with a certain assigned number were asked to fill out an electronic questionnaire with or without images regarding their feeling about muscles. A timer was used to record the time participants spent on the questionnaire. Then, same as before, the participants were assigned the power drills in a random order as conducted in advance. Then a timer was used to record the time participants spent on the driving task. In the process, participants used assigned drill to drive 9 three-inch-long screws into a non-treated 4x1.5x2 (4 inch long, 1.5 inch wide, and 2 inch thick) wood piece, and then reverse-drive the screws out. After the screw driving task, the participants were given the same electronic questionnaire regarding their feeling about muscles to fill out. Then participants had a 2-minute break before the start of the next one. The participants repeated the questionnaires and screw driving task for the second and third assigned power drills. After that, participants were also asked to fill out a questionnaire regarding their experience of the test. After the questionnaires were completed, several additional questions were in a short face-to-face interview (about 5 minutes) with the participants asking how they felt regarding the whole task process (including both the screw-driving task and the questionnaire task). A voice recorder on mobile phone was used to record the answers from the participants in the short interview. When the interview was completed, the participants ended the experiment (Figure B7).

2.4 Data Analysis

In the present study, independent and dependent variables were divided into three conditions (gender difference comparison, survey method comparison and survey influence) according to the hypotheses. Under the gender difference comparison condition, the independent variable is participants' gender and drill, and the dependent variables are feature concern, total scores of each drill and drill preference. Under the survey method comparison condition, the independent variable are survey methods which included the classic survey, the survey with images and the survey with both images and videos, and the dependent variables are the time (unit in seconds) participants spend on each survey method, and if the survey helped participants' understanding. Under the survey influence condition, the independent variable is the test type, which included drill alone and drill with survey and the dependent variable is drill preference (Table A1).

The statistical software JMP Pro 15 was selected for analyzing the data in this study. The mean differences, chi-square and p-value were used to validate the data. The researchers used Chi-Square, Two-Way ANOVA, and Two-Sample t-Test to find the mean difference and the interaction between these categories.

CHAPTER 3. RESULTS

3.1 Gender Difference Comparison

3.1.1 Female vs. Male in Feature Concerns on Using Drills

When comparing the feature concerns among our participants on using drills, the assumptions were that the sample was randomly drawn from the population, the observations were independent of each other and all expected values were at least 5. The mosaic plot was used as the way of visualizing contingency tables. The mosaic plot consists of rectangles that represent the cells in a contingency table (Hofmann, 2008). In Figure B2, the plot shows the number of participants choosing each feature by different widths of the rectangle bars. For example, the handle design bar is wider than battery because the number of female participants who chose handle design (which is 15) is more than the number of female participants who chose battery (which is 7). For the result, the plot shows us that for battery and service life, there's a larger proportion of male participants than female participants; for speed, there's larger proportion of female participants than male participants; for orientation, power, switch and weight, there's almost the same proportion between female participants and male participants. The p-value (p = .9220) shows there was no statistically significant evidence that the distribution of gender is not equal among the different feature concerns on using drills (Figure B8).

3.1.2 Female vs. Male in Feature Concerns on Purchasing Drills

When comparing the feature concerns among the participants on purchasing drills, the assumptions were that the observations were independent of each other and over 80% of expected values were at least 5. The mosaic plot showed that only for light preference, there was a larger proportion of male participants than female participants; for orientation preference, price and switch, there was almost the same proportion between female participants and male participants.

The p-value (p = .9717) shows there was no statistically significant evidence that the distribution of gender was not equal among the different feature concerns on purchasing drills (Figure B9).

3.1.3 Female vs. Male in Best Selection on Using Drills

When comparing the best drill selection among the participants, the assumption was that the observations were independent of each other. The chi-square test showed that there were 20% of expected values count less than 5, which means there were existing small expected numbers which made the p-value invalid in chi-square test. Therefore, Fisher's Exact Test was used in this case to get more accurate results. In Fisher's Exact Test, the p-value (p = .7178) shows there was no statistically significant evidence that the distribution of gender was not equal among the different drills (Figure B10).

3.1.4 Female vs. Male in Worst Selection on Using Drills

When comparing the worst drill selection among our participants, the assumption was that the observations were independent of each other. The chi-square test showed that there were 20% of expected values count less than 5, which means there were existing small expected numbers which made the p-value invalid in chi-square test. Therefore, Fisher's Exact Test was used in this case to get more accurate results. In Fisher's Exact Test, the p-value (p = 1.0000) shows there was no statistically significant evidence that the distribution of gender is not equal among the different drills (Figure B12).

In addition, the results also showed some major factors participants considered when they chose the best and the worst drill, which included drill weight, control and comfort. Among these major factors, for the best selection, the p-value (p = .4036) shows there was no statistically significant evidence that the distribution of gender was not equal among the consideration of different factors in drill selection (Figure B11); for the worst selection, the chi-square test showed that there were 20% of expected values count less than 5, which means there were existing small expected numbers which made the p-value invalid in chi-square test. Therefore, Fisher's Exact Test was used in this case to get more accurate result. In Fisher's Exact Test, the p-value (p = .8162) shows there was no statistically significant evidence that the distribution of gender was not equal among the consideration of different factors in drill selection (Figure B13).

3.1.5 Female vs. Male in Selection on Purchasing Drill

When comparing the drill selection for daily purchase among the participants, the assumption was that the observations were independent of each other. The chi-square test showed that there were 20% of expected values count less than 5, which means there were existing small expected numbers which made the p-value invalid in chi-square test. Therefore, Fisher's Exact Test was used in this case to get more accurate results. In Fisher's Exact Test, the p-value (p = 1.0000) shows there was no statistically significant evidence that the distribution of gender was not equal among the different brands of drills (Figure B14).

3.1.6 Female vs. Male in Total Scores of Drills

When comparing the mean of the total scores (the sum of control level scores, shape design scores, and comfort level scores from three different questions in the user experience feedback questionnaire) of female and male rates for each drill, the researchers observed the mean difference of -0.1492 (Makita = 0.4249, Milwaukee = -0.1961, Porter Cable = -0.6765) (Figure B15). The samples were independent and fit the normality and equal variance assumption (Figure B16). The difference was statistically significant for the drill because the p-value is p = .0027 (Figure B17). The Eta squared of drill is 0.1114, which can identify as large effect size. It means the relationship between Drill and the Total Scores of Drills were strong. However, since the p-value (p = .7366) was greater than 0.05, the mean difference of gender in the total scores of drills was no statistically significance (Figure B17).

3.2 Survey Methods Comparison

3.2.1 Classic vs. Picture assistant Spend Time

When comparing the mean of spend time between the classic survey method and picture assistance survey method, the participants filled out the survey before testing each drill, and we observed a difference of -20.847 (time in seconds), which means the mean spend time in the classic survey method is 20.847 seconds longer than in the picture assistance survey method. The difference was not statistically significant (Figure B18). For the survey participants filled out after testing each drill, we observed a difference of -24.153 (time in seconds), which means the mean spend time in the classic survey method is 24.153 seconds longer than in the picture assistance survey method. The difference was not statistically significant (Figure B19). For the participants only filled the survey after the test, we observed a difference of -41.67. The difference was not statistically significant (Figure B20).

3.2.2 Participant comprehension of All Three Survey Methods

When comparing the participant comprehension of all three survey methods (classic, picture assistance, picture & video assistance), the assumptions were that the observations were independent of each other and all expected values were at least 5. The mosaic plot showed that in the question asking the participants, who test the picture assistance method, if they noticed the name of muscles, there was a larger proportion of answers ‘No’ than ‘Yes’. In the question asking if the pictures helped to understand the questions, almost all participants answer ‘Yes’. In the question asking the participants, who tested the classic method, if they understood the name of muscles, the majority of participants answered ‘Yes’. In the question asking the participants, who tested the picture & video assistance method, if the videos help to answer the questions, there was the same proportion of ‘Yes’ and ‘No’ (Figure B21), which means the questionnaire with video assistance was not preferred by half of the participants. The p-value (p = .0094) shows there was statistically significant evidence that the distribution of participant feedback is not equal among the different survey methods (Figure B21).

3.3 Drill with Survey vs. Drill Alone Preference Difference

3.3.1 Best Drill Selection

When comparing the best drill preference by survey effect among the participants, the mosaic plot shows that there is not an obvious difference between the preference of all three drills among the participants. The chi-square test showed that there were 20% of expected values count less than 5, which means there were existing small expected numbers which made the p-value invalid in chi-square test. Therefore, Fisher's Exact Test was used in this case to get more accurate results. In Fisher's Exact Test, the p-value (p = .7868) shows there was no statistically significant evidence that the distribution of drill preference was not equal among the method of drill alone and the method of drill with the survey.

3.3.2 Worst Drill Selection

When comparing the worst drill preference by survey effect among the participants, the mosaic plot shows that there is not an obvious difference between the preference of all three drills among the participants. The chi-square test showed that there were 20% of expected values count less than 5, which means there were existing small expected numbers which made the p-value invalid in chi-square test. Therefore, Fisher's Exact Test was used in this case to get more accurate results. In Fisher's Exact Test, the p-value (p = .6394) shows there was no statistically significant evidence that the distribution of drill preference was not equal among the method of drill alone and with the survey.

3.4 Other Findings

We also observed some additional results from the experiment. From our participant feedback, the lumber's texture and testing position were two factors the participants mentioned more in the short interview. This could be associated with the perception and the effect of the drill usage. The same kind of wood (lumber) used in the experiment was found to have inconsistent softness and hardness. Therefore, the participants easily perceived different degrees of force when different drills were used.

CHAPTER 4. DISCUSSION

In this study, three hypotheses were conducted: (1) Female participants and male participants pay separate regard to different features of power drills, both using and purchasing conditions, as well as have different perceptions of the same features. (2) The questionnaire influences the decisions participants make for product preference. (3) A questionnaire with visual assistances helps participants better understand the questions and their review of the process of the experience. All three hypotheses have been partially supported and are discussed below.

4.1 Hypothesis 1: Female participants and male participants pay separate regard to different features of power drills, both using and purchasing conditions, as well as have different perceptions of the same features.

When looking for whether gender has effects on selecting drills, formally the question is: does the proportion of participants who select particular drills differ across the gender difference in our dataset?

To validate this hypothesis, we compared and plotted the proportion of feature concerns on different conditions (using and purchasing), the preference of drill selections (best/worst/purchasing), and the total scores participants rated for the drills.

However, all the results in this sections showed no significant influence in gender difference on the evaluation of power drills.

A possible explanation for this is that the effect of gender difference on the evaluation of power drills is too small to inspect by such a small sample size. Even though in the case of feature concerns, basically female participants and male participants did not show significant differences in using conditions (p-value = .9235), we can still see the obvious difference between female participants and male participants in the portions of some features such as battery and service life of a power drill. Another possible explanation could be the personal experience. In a previous study mentioned in the usability of hand tools section, the differences in ratings of tools appear to be driven by the differences in personal experience and reported confidence with use of the tools (Seol, 2005). It showed people who have had confident experiences in using a tool would have a positive impact on the rating of the usability of it. In other words, people may give higher evaluation in the tools they have had a good experience before. It can be a possible reason why in the preference of drill selections (best selection, worst selection and purchasing selection) and the total scores participants rated for the drills did not show significant differences between male participants and female participants.

4.2 Hypothesis 2: A questionnaire influences the decisions participants make for product preference.

To validate this hypothesis, we compared and plotted the proportion of preference of the drills under two conditions – drill alone and drill with the usability experience feedback survey. In general, our participants did not show significant preference differences of each drill after doing the survey (Best Selection: p-value = 0.7667, Worst Selection: p-value = 0.6011), which means the survey did not significantly influence the decision participants made in their drill preference.

However, the results supported this hypothesis with participant feedback in the short interview at the end of the experiment. Almost 83.33% of participants considered the survey helped them to easily make a better decision on drill selection. A possible explanation for this could be before doing the survey, participants had a preliminary decision on the preference of the drills through the test. The questions in the survey regarding the experience of using three drills may have helped them confirm the selection in a short term. The only factor on the usability experience feedback survey which may have had impact on participants' decision is the price, which could also help them make a better choice.

4.3 Hypothesis 3: A questionnaire with visual assistances helps participants better understand the questions.

To validate this hypothesis, we compared participant feedback from all three groups (classic, image assistant, and video assistant) at the end of the experiment. Our results supported this hypothesis with a significant difference between the classic survey and the survey with the image assistance (p-value = 0.0053). In the group with image assistance, almost all participants believed images helped them understand and answer the questions. This result may be explained by the possibility that image can deliver information faster than text. The interesting thing is, in the process of filling out the questionnaires with images, over half of the participants did not notice the related terms in the questions. In contrast, people felt it was more difficult to answer the questions due to some unfamiliar words.

The second part of this hypothesis was not supported in the group with video assistance. Only half of the participants considered the video helped them to answer the questions regarding their muscles during the test, with the other half considering it of no help. A possible explanation for this is that the video did not show a good angle of the tester's position in the video. In order to show all the muscle parts that needed to be tested, the lens angle had to be changed often when recording. This could cause the participants getting lost when watching the video. Another reason could be that it was hard for the participants to correlate their experience well with what they saw in the video. This may have impact on participants' recall of their test experience.

CHAPTER 5. CONCLUSION

From all the results, the summary of this study can be divided into three aspects.

Gender difference has no impact on the concern of the features of the drill, the preference of best, worst and purchasing selection of the drill, and the total evaluation of the drill. However, the results may be different if the sample size is large enough and many personal factors are considered.

In this study, participants preferred the questionnaire with image assistance because they believed the images helped them directly and exactly locate the muscle parts the questions referenced. It helped them save time to complete the whole survey. The questionnaire with video assistance was not preferred by half of the participants in this study. They did not believe it helped them to better answer the questions in the survey. Therefore, the high-fidelity (video) survey is not the best solution. The recommended questionnaire form was to have the questions with image assistance to descript the terms in research field, which helped participants visualize the questions and cleared their minds about what the questions asked.

Lastly, in a process of helping customers select a product, a good questionnaire may not change a customer's mind about a product preference, but it can help a customer make a reasonable and highly-educated product choice when necessary.

CHAPTER 6. FUTURE WORK

Although we looked into people’s perception of using drills, we only asked the participants to hold the drill in one position during the test. This was limiting for participants to get familiar and know well about how to use the drill. Also, the lumber’s texture used in this study was unstable. This could be one of the factors that influenced participants’ experience of using drills.

Future work could consider allowing more positions to let the participants hold the drills, such as squatting position, half squatting position or sitting position. More positions could provide participants more opportunities to feel the change of their muscles during the process of using drills. In addition, to minimize the likelihood that participants use different degrees of force when using drills, other stable materials could be used as the bases to drive screws.

Future work also could be setup based on scientific and technological development. Higher technology perhaps can provide more options to help users on product selection and decision making in the purchasing process. It would also bring more possibilities to the measurement of user satisfaction.

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APPENDIX A: LIST OF TABLES

Table A1. Independent Variables and Dependent Variables

Condition	Independent variable	Independent variable level	Dependent variable	Dependent variable level
Gender Difference Comparison	Gender	-	Feature Concern	-
	Gender	-	Drill Preference	-
	Gender		Total Score	
	Drill			
Survey Method Comparison	Survey method	1. Classic survey 2. Survey with images	Spend Time (s)	-
	Survey method	1. Classic survey 2. Survey with images 3. Survey with images and videos	Help on Understanding	1. Help understand 2. no help understand
Survey Influence	test type	1. Drill alone 2. Drill With survey	Drill preference	-

APPENDIX B: LIST OF FIGURES

Figure B1. Milwaukee 2702-20

Figure B2. Makita XPH12

Figure B3. Porter Cable PC1801D

Figure B4. Lumbers

Figure B5. Screw

Figure B6. Glove & goggle

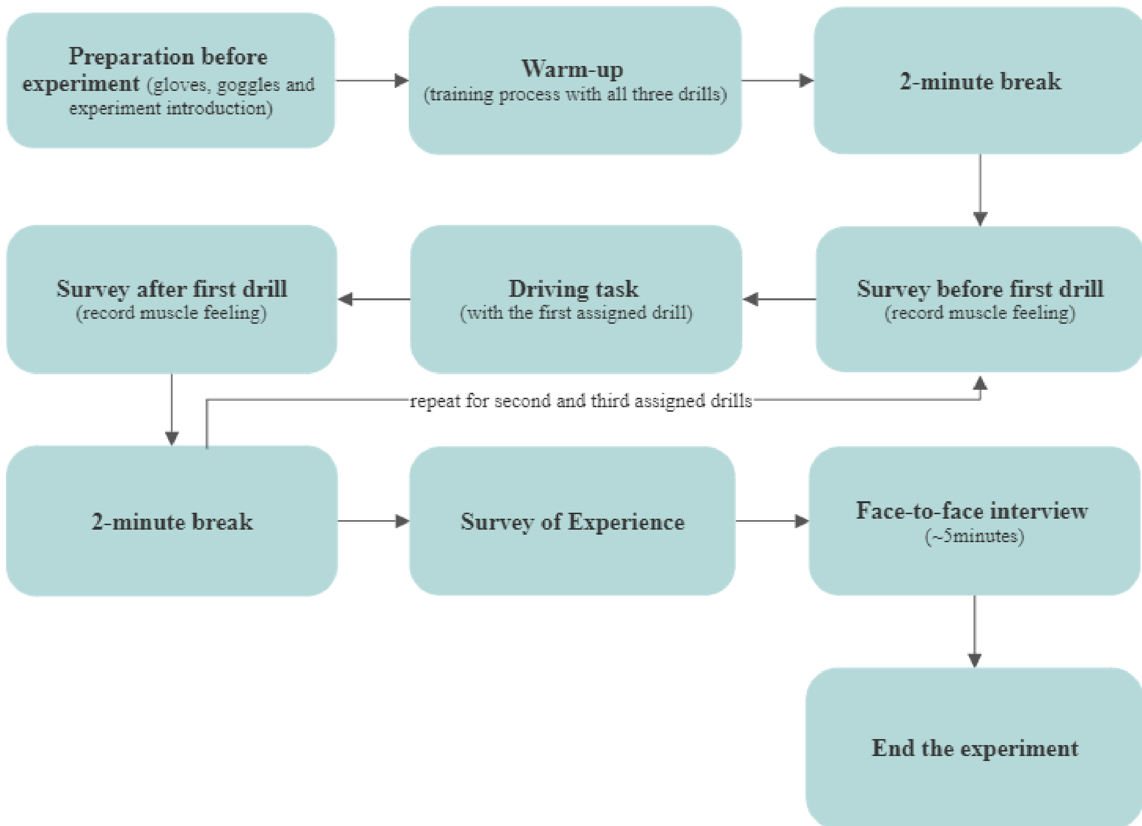
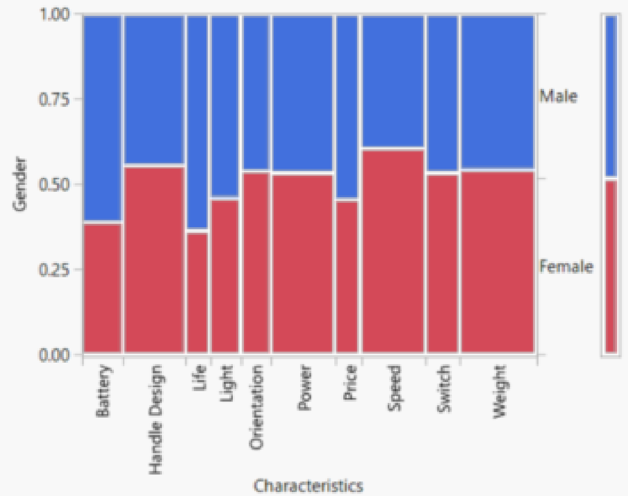


Figure B7. Experiment Procedure Flowchart

Contingency Analysis of Gender By Characteristics

Mosaic Plot



Weight: Number of Use

Tests

N	DF	-LogLike	RSquare (U)
197	9	1.9169015	0.0141

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	3.834	0.9220
Pearson	3.809	0.9235

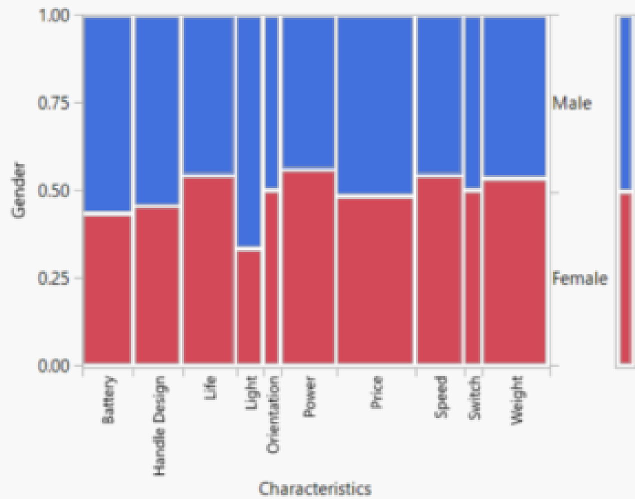
Contingency Table

Characteristics	Count / Total % / Col % / Row % / Expected	Gender: Female	Male	Total
Battery	Count	7	11	18
	Total %	3.55	5.58	9.14
	Col %	6.86	11.58	
	Row %	38.89	61.11	
	Expected	9.3198	8.6802	
Handle Design	Count	15	12	27
	Total %	7.61	6.09	13.71
	Col %	14.71	12.63	
	Row %	55.56	44.44	
	Expected	13.9797	13.0203	
Life	Count	4	7	11
	Total %	2.03	3.55	5.58
	Col %	3.92	7.37	
	Row %	36.36	63.64	
	Expected	5.69543	5.30457	
Light	Count	6	7	13
	Total %	3.05	3.55	6.60
	Col %	5.88	7.37	
	Row %	46.15	53.85	
	Expected	6.73096	6.26904	
Orientation	Count	7	6	13
	Total %	3.55	3.05	6.60
	Col %	6.86	6.32	
	Row %	53.85	46.15	
	Expected	6.73096	6.26904	
Power	Count	15	13	28
	Total %	7.61	6.60	14.21
	Col %	14.71	13.68	
	Row %	53.57	46.43	
	Expected	14.4975	13.5025	
Price	Count	5	6	11
	Total %	2.54	3.05	5.58
	Col %	4.90	6.32	
	Row %	45.45	54.55	
	Expected	5.69543	5.30457	
Speed	Count	17	11	28
	Total %	8.63	5.58	14.21
	Col %	16.67	11.58	
	Row %	60.71	39.29	
	Expected	14.4975	13.5025	
Switch	Count	8	7	15
	Total %	4.06	3.55	7.61
	Col %	7.84	7.37	
	Row %	53.33	46.67	
	Expected	7.7665	7.2335	
Weight	Count	18	15	33
	Total %	9.14	7.61	16.75
	Col %	17.65	15.79	
	Row %	54.55	45.45	
	Expected	17.0863	15.9137	
Total	Count	102	95	197
	Total %	51.78	48.22	

Figure B8. Features Concern by Gender (using drill)

Contingency Analysis of Gender By Characteristics

Mosaic Plot



Weight: Number of Purchase

Tests

N	DF	-LogLike	RSquare (U)
209	9	1.4003524	0.0097

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	2.801	0.9717
Pearson	2.772	0.9726

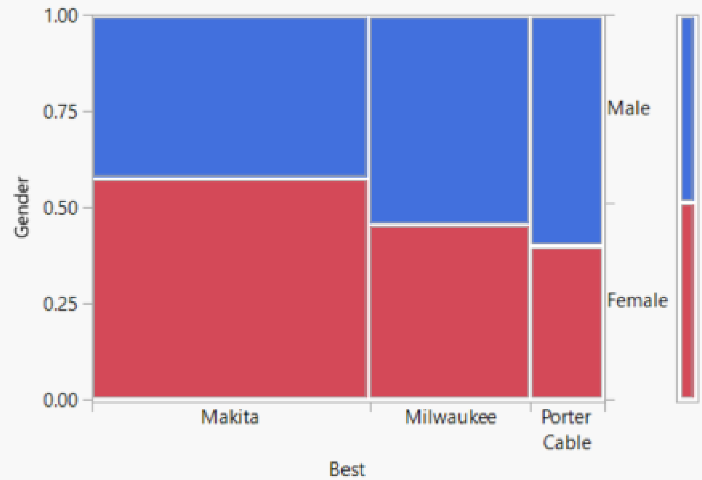
Contingency Table

Characteristics	Gender: Female	Male	Total
Count			
Total %			
Col %			
Row %			
Expected			
	4.78	6.22	11.00
	9.62	12.38	
	43.48	56.52	
	11.445	11.555	
Handle Design	10	12	22
	4.78	5.74	10.53
	9.62	11.43	
	45.45	54.55	
	10.9474	11.0526	
Life	13	11	24
	6.22	5.26	11.48
	12.50	10.48	
	54.17	45.83	
	11.9426	12.0574	
Light	4	8	12
	1.91	3.83	5.74
	3.85	7.62	
	33.33	66.67	
	5.97129	6.02871	
Orientation	4	4	8
	1.91	1.91	3.83
	3.85	3.81	
	50.00	50.00	
	3.98086	4.01914	
Power	14	11	25
	6.70	5.26	11.96
	13.46	10.48	
	56.00	44.00	
	12.4402	12.5598	
Price	17	18	35
	8.13	8.61	16.75
	16.35	17.14	
	48.57	51.43	
	17.4163	17.5837	
Speed	12	10	22
	5.74	4.78	10.53
	11.54	9.52	
	54.55	45.45	
	10.9474	11.0526	
Switch	4	4	8
	1.91	1.91	3.83
	3.85	3.81	
	50.00	50.00	
	3.98086	4.01914	
Weight	16	14	30
	7.66	6.70	14.35
	15.38	13.33	
	53.33	46.67	
	14.9282	15.0718	
Total	104	105	209
	49.76	50.24	

Figure B9. Features Concern by Gender (purchasing drill)

Contingency Analysis of Gender By Best

Mosaic Plot



Contingency Table

Best	Count / Total % / Col % / Row % / Expected	Female	Male	Total
Makita	Count	11	8	19
	Total %	31.43	22.86	54.29
	Col %	61.11	47.06	
	Row %	57.89	42.11	
	Expected	9.77143	9.22857	
Milwaukee	Count	5	6	11
	Total %	14.29	17.14	31.43
	Col %	27.78	35.29	
	Row %	45.45	54.55	
	Expected	5.65714	5.34286	
Porter Cable	Count	2	3	5
	Total %	5.71	8.57	14.29
	Col %	11.11	17.65	
	Row %	40.00	60.00	
	Expected	2.57143	2.42857	
Total	Count	18	17	35
	Total %	51.43	48.57	

Tests

N	DF	-LogLike	RSquare (U)
35	2	0.36974343	0.0152

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	0.739	0.6909
Pearson	0.737	0.6919

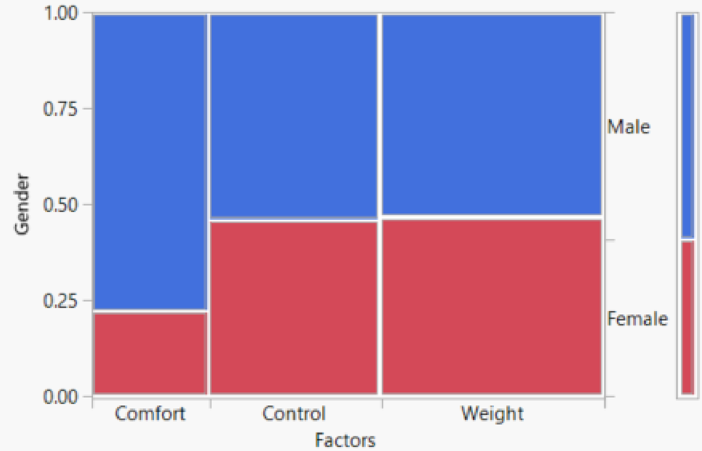
Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

Fisher's Exact Test	Table Probability (P)	Two-Sided Prob ≤ P
	0.076955	0.7178

Figure B10. Best Drill Selection

Contingency Analysis of Gender By Factors

Mosaic Plot



Weight: Best Selection

Contingency Table

Factors	Count / Total % / Col % / Row % / Expected	Female	Male	Total
Comfort	Count	2	7	9
	Total %	5.13	17.95	23.08
	Col %	12.50	30.43	
	Row %	22.22	77.78	
	Expected	3.69231	5.30769	
Control	Count	6	7	13
	Total %	15.38	17.95	33.33
	Col %	37.50	30.43	
	Row %	46.15	53.85	
	Expected	5.33333	7.66667	
Weight	Count	8	9	17
	Total %	20.51	23.08	43.59
	Col %	50.00	39.13	
	Row %	47.06	52.94	
	Expected	6.97436	10.0256	
Total	Count	16	23	39
	Total %	41.03	58.97	

Tests

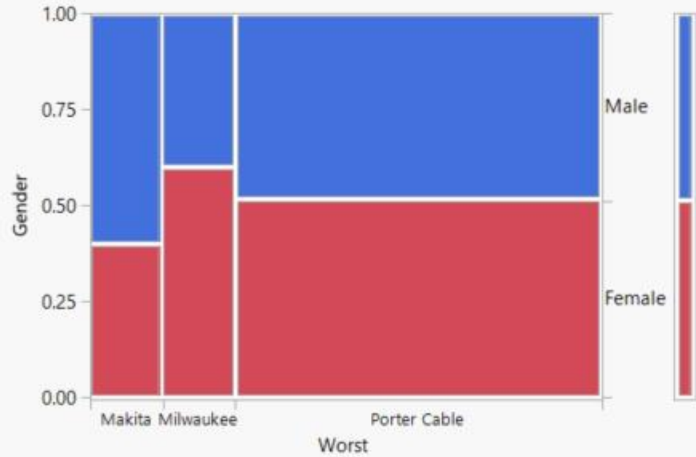
N	DF	-LogLike	RSquare (U)
39	2	0.90727478	0.0344

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	1.815	0.4036
Pearson	1.712	0.4248

Figure B11. Major factors in consideration of best drill selection

Contingency Analysis of Gender By Worst

Mosaic Plot



Contingency Table

Worst	Count / Total % / Col % / Row % / Expected	Female	Male	Total
Makita	Count	2	3	5
	Total %	5.71	8.57	14.29
	Col %	11.11	17.65	
	Row %	40.00	60.00	
	Expected	2.57143	2.42857	
Milwaukee	Count	3	2	5
	Total %	8.57	5.71	14.29
	Col %	16.67	11.76	
	Row %	60.00	40.00	
	Expected	2.57143	2.42857	
Porter Cable	Count	13	12	25
	Total %	37.14	34.29	71.43
	Col %	72.22	70.59	
	Row %	52.00	48.00	
	Expected	12.8571	12.1429	
Total	Count	18	17	35
	Total %	51.43	48.57	

Tests

N	DF	-LogLike	RSquare (U)
35	2	0.20707281	0.0085

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	0.414	0.8130
Pearson	0.412	0.8139

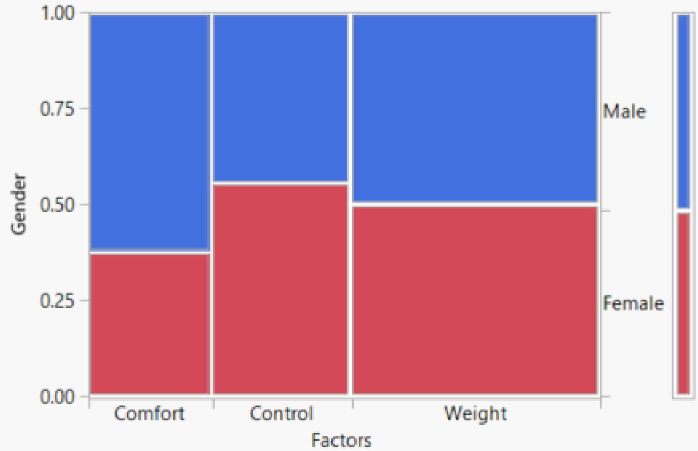
Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

Fisher's Exact Test	Table Probability (P)	Two-Sided Prob ≤ P
	0.114605	1.0000

Figure B12. Worst Drill Selection

Contingency Analysis of Gender By Factors

Mosaic Plot



Weight: Worst Selection

Contingency Table

Gender

Factors	Count / Total % / Col % / Row % / Expected	Female	Male	Total
Comfort	Count	3	5	8
	Total %	9.09	15.15	24.24
	Col %	18.75	29.41	
	Row %	37.50	62.50	
	Expected	3.87879	4.12121	
Control	Count	5	4	9
	Total %	15.15	12.12	27.27
	Col %	31.25	23.53	
	Row %	55.56	44.44	
	Expected	4.36364	4.63636	
Weight	Count	8	8	16
	Total %	24.24	24.24	48.48
	Col %	50.00	47.06	
	Row %	50.00	50.00	
	Expected	7.75758	8.24242	
Total	Count	16	17	33
	Total %	48.48	51.52	

Tests

N	DF	-LogLike	RSquare (U)
33	2	0.29318814	0.0128

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	0.586	0.7459
Pearson	0.581	0.7478

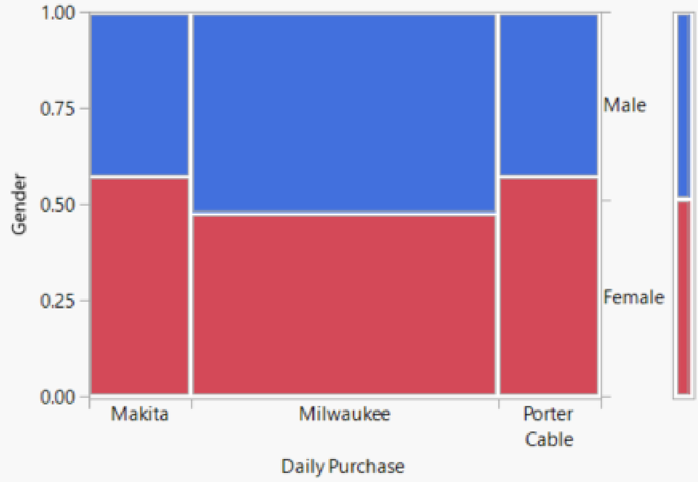
Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

Fisher's Exact Test	Table Probability (P)	Two-Sided Prob ≤ P
	0.077829	0.8162

Figure B13. Major factors in consideration of worst drill selection

Contingency Analysis of Gender By Daily Purchase

Mosaic Plot



Contingency Table

Daily Purchase	Count Total % Col % Row % Expected	Gender: Female	Male	Total
Makita	Count	4	3	7
	Total %	11.43	8.57	20.00
	Col %	22.22	17.65	
	Row %	57.14	42.86	
	Expected	3.6	3.4	
Milwaukee	Count	10	11	21
	Total %	28.57	31.43	60.00
	Col %	55.56	64.71	
	Row %	47.62	52.38	
	Expected	10.8	10.2	
Porter Cable	Count	4	3	7
	Total %	11.43	8.57	20.00
	Col %	22.22	17.65	
	Row %	57.14	42.86	
	Expected	3.6	3.4	
Total	Count	18	17	35
	Total %	51.43	48.57	

Tests

N	DF	-LogLike	RSquare (U)
35	2	0.15287793	0.0063

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	0.306	0.8582
Pearson	0.305	0.8586

Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

Fisher's Exact Test	Table Probability (P)	Two-Sided Prob ≤ P
	0.095222	1.0000

Figure B14. Drill Selection on Purchasing

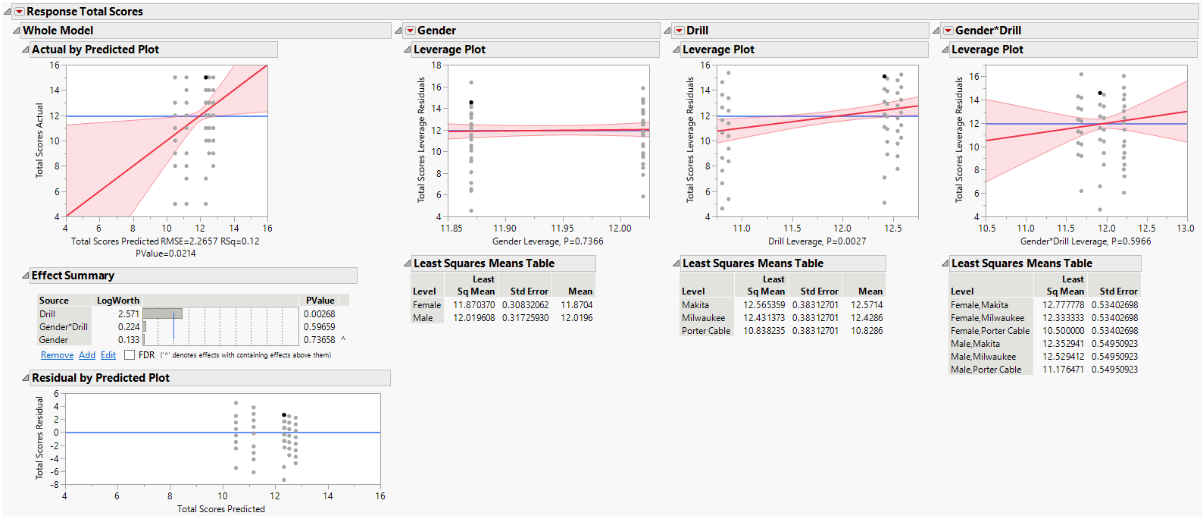


Figure B15. Total Score of Each Drill (Mean Different)

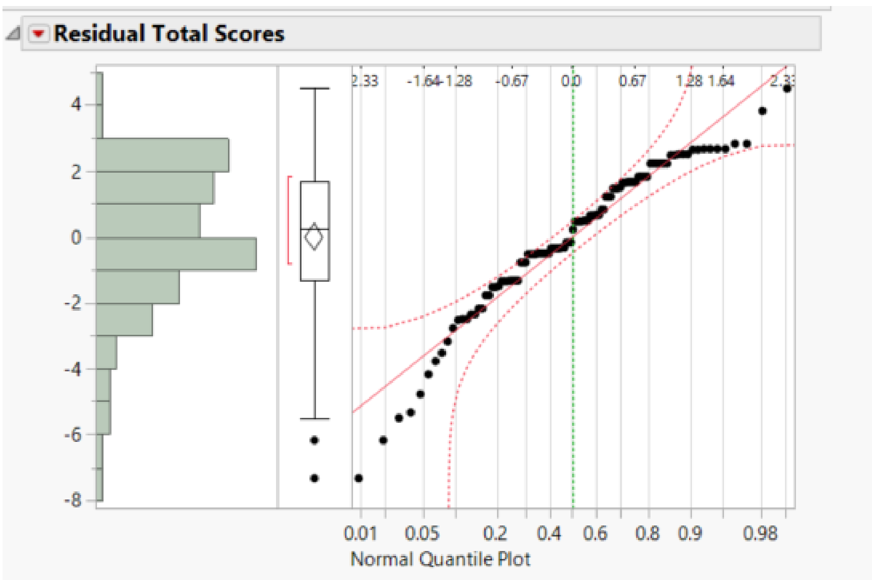


Figure B16. Residual Distribution of Total Scores

Summary of Fit

RSquare	0.123276
RSquare Adj	0.078997
Root Mean Square Error	2.265685
Mean of Response	11.94286
Observations (or Sum Wgts)	105

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	71.45780	14.2916	2.7841
Error	99	508.19935	5.1333	Prob > F
C. Total	104	579.65714		0.0214*

Parameter Estimates

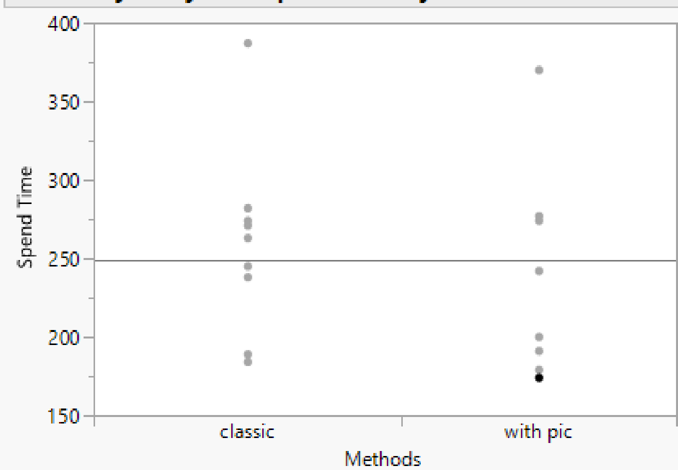
Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	11.944989	0.221198	54.00	<.0001*
Gender[Female]	-0.074619	0.221198	-0.34	0.7366
Drill[Makita]	0.6203704	0.312822	1.98	0.0501
Drill[Milwaukee]	0.4863834	0.312822	1.55	0.1232
Gender[Female]*Drill[Makita]	0.287037	0.312822	0.92	0.3611
Gender[Female]*Drill[Milwaukee]	-0.02342	0.312822	-0.07	0.9405

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Gender	1	1	0.584158	0.1138	0.7366
Drill	2	2	64.568876	6.2892	0.0027*
Gender*Drill	2	2	5.330781	0.5192	0.5966

Figure B17. Total Score of Each Drill (p-value)

Oneway Analysis of Spend Time By Methods



t Test

with pic-classic

Assuming unequal variances

Difference	-20.847	t Ratio	-0.67371
Std Err Dif	30.944	DF	14.17281
Upper CL Dif	45.445	Prob > |t|	0.5113
Lower CL Dif	-87.139	Prob > t	0.7443
Confidence	0.95	Prob < t	0.2557

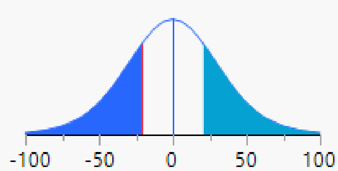


Figure B18. Classic and Image Assistance Survey Method Spend Time Before the Test

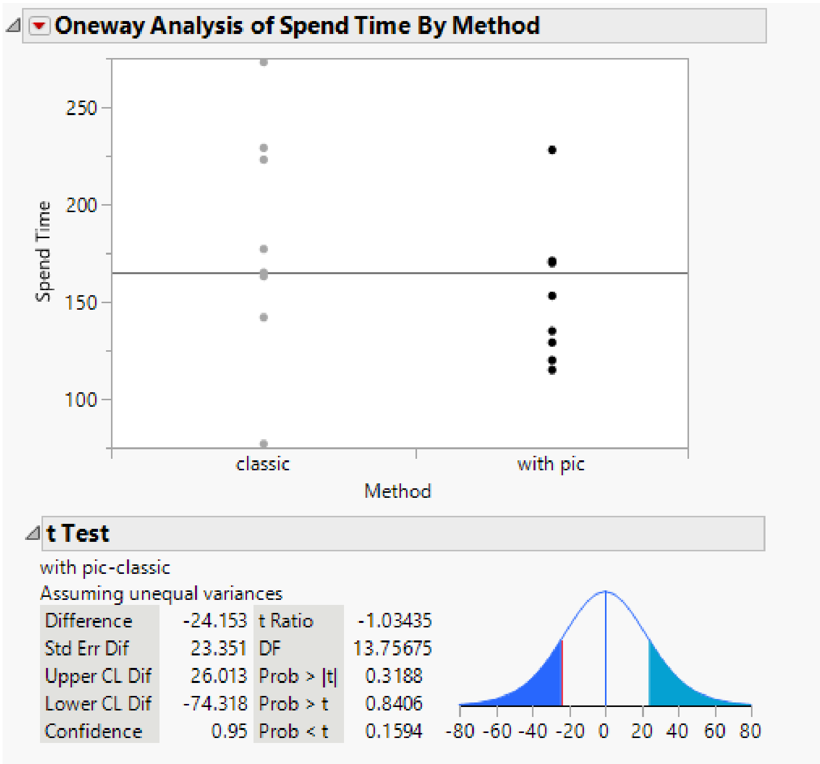


Figure B19. Classic and Image Assistance Survey Method Spend Time After the Test

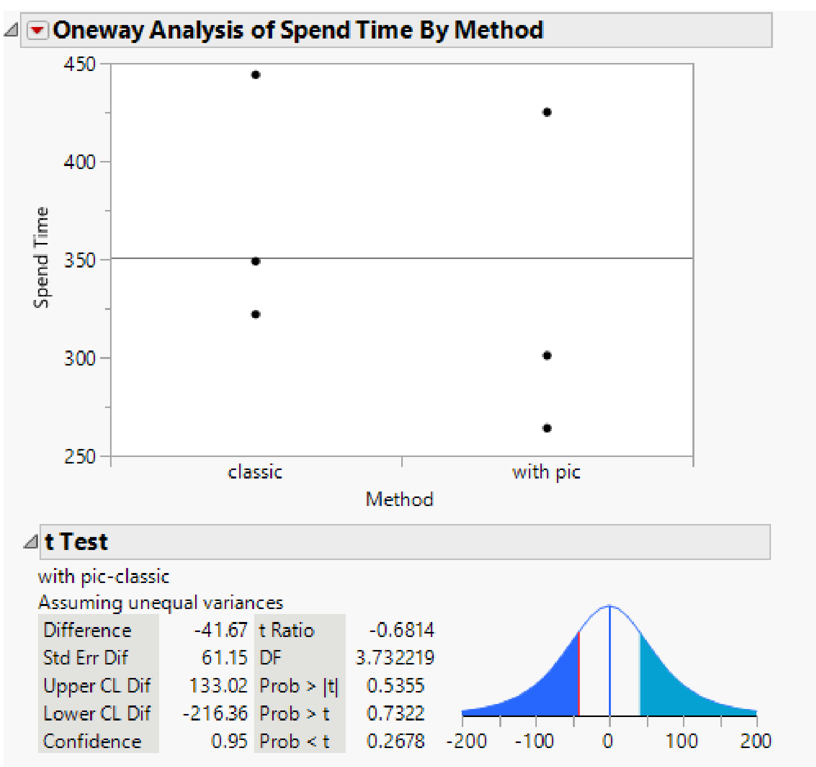
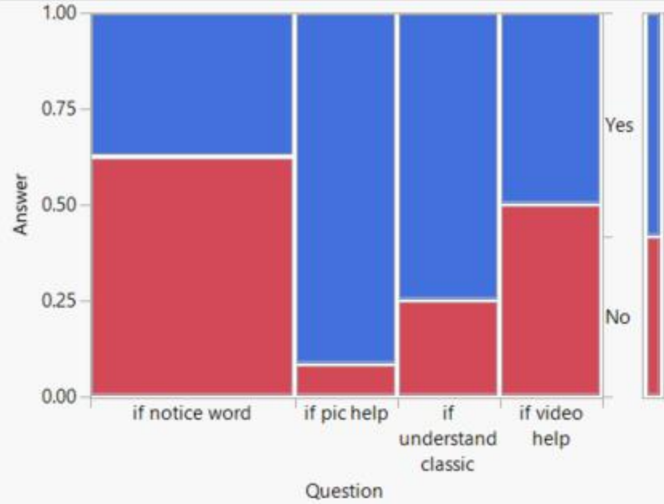


Figure B20. Classic and Image Assistance Survey Method Spend Time Only After the Test

Contingency Analysis of Answer By Question

Mosaic Plot



Weight: Number

Contingency Table

Question	Count / Total % / Col % / Row % / Expected	No	Yes	Total
if notice word	Count	15	9	24
	Total %	25.00	15.00	40.00
	Col %	60.00	25.71	
	Row %	62.50	37.50	
	Expected	10	14	
if pic help	Count	1	11	12
	Total %	1.67	18.33	20.00
	Col %	4.00	31.43	
	Row %	8.33	91.67	
	Expected	5	7	
if understand classic	Count	3	9	12
	Total %	5.00	15.00	20.00
	Col %	12.00	25.71	
	Row %	25.00	75.00	
	Expected	5	7	
if video help	Count	6	6	12
	Total %	10.00	10.00	20.00
	Col %	24.00	17.14	
	Row %	50.00	50.00	
	Expected	5	7	
Total	Count	25	35	60
	Total %	41.67	58.33	

Tests

N	DF	-LogLike	RSquare (U)
60	3	6.3662585	0.1562

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	12.733	0.0053*
Pearson	11.486	0.0094*

Figure B21. Participants' Understanding by Survey Method

APPENDIX C: ATTACHMENTS

Experiment Document: IRB Approval

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
2420 Lincoln Way, Suite 202
Ames, Iowa 50014
515 294-4566

Date: 06/27/2019

To: Yijia Sun Richard T Stone

From: Office for Responsible Research

Title: **Customer Satisfaction and Effect of Survey Design in a Tool Usability Testing**

IRB ID: **19-094**

Submission Type: Modification **Review Type:** Expedited

Approval Date: 06/27/2019 **Approval Expiration Date: N/A**

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- **Use only the approved study materials** in your research, including the **recruitment materials and informed consent documents that have the IRB approval stamp.**
- Retain signed informed consent documents **for 3 years after the close of the study,** when documented consent is required.
- **Obtain IRB approval prior to implementing** any changes to the study or study materials.
- **Promptly inform the IRB of any addition of or change in federal funding for this study.** Approval of the protocol referenced above applies only to funding sources that are specifically identified in the corresponding IRB application.
- **Inform the IRB if the Principal Investigator and/or Supervising Investigator end their role or involvement with the project** with sufficient time to allow an alternate PI/Supervising Investigator to assume oversight responsibility. Projects must have an eligible PI to remain open.
- **Immediately inform the IRB of (1) all serious and/or unexpected** adverse experiences involving risks to subjects or others; and (2) **any other** unanticipated problems **involving risks to subjects or others.**
- IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. **Approval from other entities may also be needed.** For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of

those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **IRB approval in no way implies or guarantees that permission from these other entities will be granted.**

- Your research study may be subject to **post-approval monitoring by Iowa State University's Office for Responsible Research**. In some cases, it may also be subject to formal audit or inspection by federal agencies and study sponsors.

- Upon completion of the project, transfer of IRB oversight to another IRB, or departure of the PI and/or Supervising Investigator, please initiate a Project Closure to officially close the project. For information on instances when a study may be closed, please refer to the IRB Study Closure Policy.

If your study requires continuing review, indicated by a specific Approval Expiration Date above, you should:

- **Stop all human subjects research activity if IRB approval lapses**, unless continuation is necessary to prevent harm to research participants. Human subjects research activity can resume once IRB approval is re-established.

- **Submit an application for Continuing Review** at least three to four weeks prior to the **Approval Expiration Date** as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.

Experiment Document: Consent Document

ISU IRB: 19-094-00
Approved Date: 06/27/2019
Expiration Date: N/A

Informed Consent Document

Study Title: User testing and Survey design comparison

Investigator: Yijia Sun, Dr. Richard Stone

INTRODUCTION

The purpose of this research study is to measure customer satisfaction with three hand-held electric drills, as well as to determine the best version of survey questionnaires to use for gaining user feedback. You should not participate if under the age of 18 and/or do not have the ability to operate a hand-held electric drill.

DESCRIPTION OF PROCEDURES

If you agree to participate in the study, you will be asked to drive screws into a piece of wood on a vertical surface and drive them out using three preselected electric drills. During the screw driving process, your time will be recorded. After drilling, you will be asked to complete four electronic questionnaires as well as a brief interview (about five minutes). In total, your participation is expected to last approximately 60 minutes or less.

RISKS OR DISCOMFORTS

While participating in this study you may experience the following risks or discomforts:

- Muscle or joint pain/soreness from exercise;
- Being poked by small splinters in the wood surface;
- Being poked by the screws themselves.

In order to avoid these injury risks, you will be clearly introduced how to safely operate the drill to drill screws into the wood surface prior to any study tasks. You are required to wear long sleeves, fully covered shoes and pants during the experiment. Also, protective gloves and safety goggles appropriate for drilling will be provided, and you will be required to wear these during the study.

RESEARCH INJURY

Please tell the researchers if you believe you have any injuries caused by your participation in the study. The researchers may be able to assist you with locating emergency treatment, if appropriate, but you or your insurance company will be responsible for the cost. Eligible Iowa State University students may obtain treatment from the Thielen Student Health Center. By agreeing to participate in the study, you do not give up your right to seek payment if you are harmed as a result of being in this study. However, claims for payment sought from the University will only be paid to the extent permitted by Iowa law, including the Iowa Tort Claims Act (Iowa Code Chapter 669).

BENEFIT

ISU IRB: 19-094-00
Approved Date: 06/27/2019
Expiration Date: N/A

Participants will not receive direct benefits. However, knowledge gained via this study can be expected to ultimately provide significant opportunities to improve the user testing process of drilling products.

PARTICIPANT RIGHTS

Participating in this study is completely voluntary. You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. You can skip any questions that you do not wish to answer.

If you have any questions about the right of research subjects or research-related injury, please contact the IRB Administrator, (515)294-4566, IRB@iastate.edu, or Director, (515)294-3115, at the Office for Responsible Research.

CONFIDENTIALITY

Records identifying participants and the future use of data will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available without your permission. However, it is possible that other people and offices responsible for making sure research is done safely and responsibly will see your information. This includes federal government regulatory agencies, auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy study records for quality assurance and data analysis. This records may contain private information.

To ensure confidentiality to the extent permitted by law, all your information will be kept confidential. Your study data will be labeled using a participant number that will remain unlinked to your identity. Study data will be stored in a locked filing cabinet and/or a password-protected, encrypted computer.

The only identifier collected, your name, will appear on this consent document, which will be stored in a locked filing cabinet, separate of any study data.

Information about you will *only* be used by the research team for the project described in this document.

QUESTIONS

You are encouraged to ask questions at any time during this study. For further information ***about the study,*** you may contact the supervisor faculty Dr. Richard T. Stone, rstone@iastate.edu or Principle investigator Yijia Sun, yijias@iastate.edu.

CONSENT AND AUTHORIZATION PROVISIONS

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

ISU IRB: 19-094-00
Approved Date: 06/27/2019
Expiration Date: N/A

Participant's Name (Printed)____

Participant's Signature _______________________________ Date _____________________________

Experiment Document: Survey

Makita 18V Feedback

* Required

Untitled Section

1. Participant No. *

____

2. Gender *

Mark only one oval.

- ( ) Male
- ( ) Female
- ( ) Other: ______________________

3. Hand Use *

Mark only one oval.

- ( ) Left Hand
- ( ) Right Hand

Background 1

4. Have you used power drill before? *

Mark only one oval.

- ( ) Yes *Skip to question 5*
- ( ) No *Skip to question 6*

Background 2

5. How do you rate your skill level of using power drill? *

Mark only one oval.

- Novice
- Experienced
- Expert

Before Drilling Feedback

Body Muscle Comfort Level

6. According to the scale below, how do you rate your comfort level of your deltoid muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable						Comfortable

7. According to the scale below, how do you rate your comfort level of your trapezius muscle? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable						Comfortable

8. According to the scale below, how do you rate your comfort level of your biceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

9. According to the scale below, how do you rate your comfort level of your triceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

10. According to the scale below, how do you rate your comfort level of your forearm muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

11. According to the scale below, how do you rate your comfort level of your latissimus dorsi? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

12. According to the scale below, how do you rate your comfort level of your quadriceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

13. According to the scale below, how do you rate your comfort level of your gastrocnemius (calf muscles)?

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

Hand Comfort Level

14. Before the test, how do you rate the comfort level of your thumb? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

15. Before the test, how do you rate the comfort level of your index finger? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

16. Before the test, how do you rate the comfort level of your middle finger, ring finger and pinkie finger? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

17. Before the test, how do you rate the comfort level of your palm? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

18. Before the test, how do you rate the comfort level of your wrist? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

End Drilling Feedback

Pause here and fill AFTER you finish the drilling task!

Body Muscle Comfort Level

19. According to the scale below, how do you rate your comfort level of your deltoid muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

20. According to the scale below, how do you rate your comfort level of your trapezius muscle? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

21. According to the scale below, how do you rate your comfort level of your biceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

22. According to the scale below, how do you rate your comfort level of your triceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

23. According to the scale below, how do you rate your comfort level of your forearm muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

24. According to the scale below, how do you rate your comfort level of your latissimus dorsi? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

25. According to the scale below, how do you rate your comfort level of your quadriceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

26. According to the scale below, how do you rate your comfort level of your gastrocnemius (calf muscles)?

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

Hand Comfort Level

27. How do you rate the comfort level of your thumb? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

28. How do you rate the comfort level of your index finger? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

29. How do you rate the comfort level of your middle finger, ring finger and pinkie finger? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

30. How do you rate the comfort level of your palm? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

31. How do you rate the comfort level of your wrist? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

(With Images) Makita 18V Feedback

* Required

1. Participant No. *

2. Gender *

Mark only one oval.

- Male
- Female
- Other: ________________

3. Hand Use *

Mark only one oval.

- Left Hand
- Right Hand

Background 1

4. Have you used power drill before? *

Mark only one oval.

- Yes *Skip to question 5*
- No *Skip to question 6*

Background 2

5. How do you rate your skill level of using power drill? *

Mark only one oval.

- Novice
- Experienced
- Expert

Before Drilling Feedback

Body Muscle Comfort Level

6. According to the scale below, how do you rate your comfort level of your deltoid muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable						Comfortable

7. According to the scale below, how do you rate your comfort level of your trapezius muscle? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

8. According to the scale below, how do you rate your comfort level of your biceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

9. According to the scale below, how do you rate your comfort level of your triceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

10. According to the scale below, how do you rate your comfort level of your forearm muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

11. According to the scale below, how do you rate your comfort level of your latissimus dorsi? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

12. According to the scale below, how do you rate your comfort level of your quadriceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

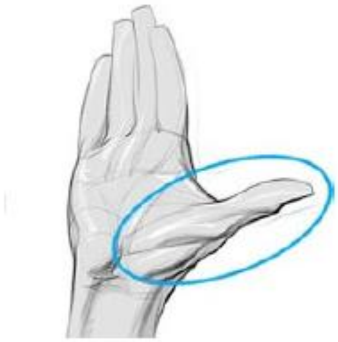
13. According to the scale below, how do you rate your comfort level of your gastrocnemius (calf muscles)? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

Hand Comfort Level

14. Before the test, how do you rate the comfort level of your thumb? *



Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

15. Before the test, how do you rate the comfort level of your index finger? *

Mark only one oval.

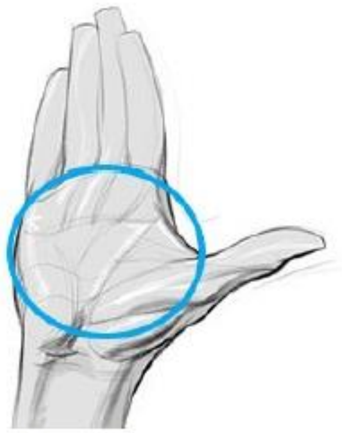
	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

16. Before the test, how do you rate the comfort level of your middle finger, ring finger and pinkie finger? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

17. Before the test, how do you rate the comfort level of your palm? *



Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

18. Before the test, how do you rate the comfort level of your wrist? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

End Drilling Feedback

Pause here and fill AFTER you finish the drilling task!

Body Muscle Comfort Level

19. According to the scale below, how do you rate your comfort level of your deltoid muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

20. According to the scale below, how do you rate your comfort level of your trapezius muscle? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

21. According to the scale below, how do you rate your comfort level of your biceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

22. According to the scale below, how do you rate your comfort level of your triceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

23. According to the scale below, how do you rate your comfort level of your forearm muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

24. According to the scale below, how do you rate your comfort level of your latissimus dorsi? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

25. According to the scale below, how do you rate your comfort level of your quadriceps muscles? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

26. According to the scale below, how do you rate your comfort level of your gastrocnemius (calf muscles)? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

Hand Comfort Level

27. How do you rate the comfort level of your thumb? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

28. How do you rate the comfort level of your index finger? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

29. How do you rate the comfort level of your middle finger, ring finger and pinkie finger? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

30. How do you rate the comfort level of your palm? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

31. How do you rate the comfort level of your wrist? *

Mark only one oval.

	1	2	3	4	5	
Uncomfortable	⬭	⬭	⬭	⬭	⬭	Comfortable

Usability Experience Feedback

* Required

1. **Participant No.** *

2. **Gender** *

   Mark only one oval.

   - Male
   - Female
   - Other:

Tool Comparison

How easy do you feel to control each tool during the test?

3. **Milwaukee 18V** *

   Mark only one oval.

	1	2	3	4	5	
Difficult to control						Easy to control

4. **Makita 18V** *

   Mark only one oval.

	1	2	3	4	5	
Difficult to control						Easy to control

5. **Porter Cable 18V** *

   Mark only one oval.

	1	2	3	4	5	
Difficult to control						Easy to control

How do you like the shape (pistol-grip design) of each tool you use during the test?

6. **Milwaukee 18V** *
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Love it

7. **Makita 18V** *
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Love it

8. **Porter Cable 18V** *
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Love it

According to the scale below, please rate the comfort level of each tool you use during the test.

9. **Milwaukee 18V** *
Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

10. **Makita 18V** *
Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

11. **Porter Cable 18V** *
Mark only one oval.

	1	2	3	4	5	
Uncomfortable	◯	◯	◯	◯	◯	Comfortable

12. **Do you like the power drill with the light on it?**
Mark only one oval.

- Yes
- No

13. **What kind of characteristics of the power drill you care when you use it?** *
Check all that apply.

- handle design
- weight
- switch
- light
- power
- orientation
- speed
- battery
- price
- life
- Other: ______________________

14. **What kind of characteristics of the power drill you care when you have to purchase it?** *
Check all that apply.

- handle design
- weight
- switch
- light
- power
- orientation
- speed
- battery
- price
- life
- Other: ______________________

15. **Do you have any other consideration when you have to purchase a power drill?** *
Mark only one oval.

- Yes
- No

16. **Please list your consideration if you answer "Yes" on the last question. (Type "pass" if you answer "No" on the last question)** *

Brand Comparison

17. **Compared with these three power drills' capabilities, which one do you think works the BEST for you?** *

Mark only one oval.

- Milwaukee 18V
- Makita 18V
- Porter Cable 18V

18. **Compared with these three power drills' capabilities, which one do you think works the WORST for you?** *

Mark only one oval.

- Milwaukee 18V
- Makita 18V
- Porter Cable 18V

19. **Combine with these three drills' capabilities and prices, which one would you like to buy for your daily needs? (Price in the brackets is for the total tool kit, includes one tool, one battery and one charger)** *

Mark only one oval.

- Milwaukee 18V ($229.20)
- Makita 18V ($278.00)
- Porter Cable 18V ($199.97)

Experiment Document: Short Interview

Brief Interview Questions

We will ask the participants the following questions for the short interview:

1. Did you have any difficulty doing the drilling task?
2. Do you have any suggestions regarding to the drilling task?
3. Did you understand all the vocabularies in the questionnaires? (only for the participants who take the questionnaires without images)
4. Have you notice the vocabularies in the muscle questionnaires? (only for the participants who take the questionnaires with images and with video)
5. Do you think the images helps you to answer the questions? How? (only for the participants who take the second data collection method)
6. Do you think the video helps you to answer the questions? How? (only for the participants who take the third data collection method)
7. Did you have any difficulty filling out the questionnaires?
8. Do you have any suggestions regarding to this questionnaires?
9. How did you choose your best/worst drill preference?
10. Do you think the last survey help you to make a better preference choice?